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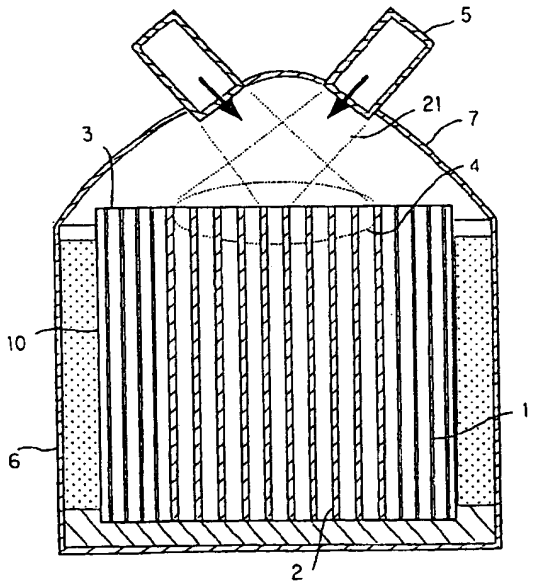
(54) HONEYCOMB STRUCTURAL BODY, AND HONEYCOMB FILTER AND CONVERTER SYSTEM USING THE HONEYCOMB STRUCTURAL BODY

(57) A honeycomb structure in which a plurality of through-holes 3 extending in the axial direction are formed by a plurality of partition walls 1 and 2, wherein the plurality of partition walls 1 and 2 are constituted by a plurality of partition walls having different thicknesses and, of the plurality of partition walls having different thicknesses, those partition walls 2 having a thickness larger than the average thickness of all partition walls are provided at a higher proportion in a particular portion of the honeycomb structure whole portion having partition walls than in other portion. This honeycomb structure, and a honeycomb filter and a converter system both using the honeycomb structure satisfy recent years' requirements of improvement in warm-up property connected with purification ability and reduction in harmful substance emitted right after engine start, and yet have a sufficient mechanical strength to external pressure, a high erosion resistance and a high thermal shock resistance.

FIG.1



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-A-58-19743, since relatively thick partition walls and relatively thin partition walls are provided uniformly, the strength of whole structure is made larger but there was also a problem of reduced thermal shock resistance.

[0011] Meanwhile, there was proposed a honeycomb structure wherein the thickness of partition walls is made larger only at the structure end at which an exhaust gas is introduced, for improvement in erosion resistance (JP-A-2000-51710).

[0012] In this honeycomb structure as well, no consideration was made to that the erosion phenomenon arising in connection with the above-mentioned recent years' requirements of thinner partition walls of honeycomb structure and mounting of converter system right below exhaust manifold is seen mostly only at the particular area of honeycomb structure end.

[0013] Further, since each partition wall has a thick portion and a thin portion pr se, a thermal stress tends to concentrate at the boundary of the thick portion and the thin portion and therefore no sufficient thermal shock resistance could be obtained.

[0014] The present invention has been made in view of the above problems. The present invention aims at providing a honeycomb structure, etc. all of which satisfy recent years' requirements of improvement in warm-up property connected with purification ability and reduction in the amount of harmful substance emitted right after engine start and yet have a sufficient mechanical strength to external pressure, a high erosion resistance and a high thermal shock resistance.

Disclosure of the Invention

[0015] The present inventors made an intensive study in order to achieve the above aim. As a result, the present inventors first found that, with respect to the mechanism of the erosion of honeycomb structure, out of the following possible factors, the factors (1) to (3) are main factors of the erosion.

(1) Foreign matter having very small particle diameters collides with partition walls of honeycomb structure and damages them; it is repeated; thereby, erosion is invited.
(2) Partition walls are damaged by fragments of damaged partition walls; this also invites erosion.
(3) Foreign matter having very large particle diameters collides with partition walls and damages them; further, such foreign matter slides on the end face of honeycomb structure, resulting in scooping-out of the end surface.
(4) There may also appear microcracks caused by thermal shock, or wind erosion caused by the shock wave brought about by pulsation of exhaust gas.

[0016] Next, with respect to the causes of erosion of honeycomb structure, the present inventors found the followings.

(1) An exhaust manifold, when produced in one piece using cast iron, undergoes oxidation at the inner wall surface during the use, to form an oxide scale and become fragile; this oxide scale is peeled by an exhaust gas flow and becomes foreign matter having particle diameters of several tens of μm; the foreign matter is carried by the exhaust gas flow and arrives at a honeycomb structure.
(2) When an exhaust manifold is produced by subjecting a stainless steel thin sheet to welding, its inner wall surface is hardly oxidized and, therefore, formation of oxide scale occurs hardly as compared with when the exhaust manifold is produced using cast iron; however, detached materials derived from spatters which have adhered on the inner wall surface of exhaust manifold during welding, or from welds such as welding beads and the like (the detached materials, when derived from spatters, have particle diameters of 1 mm to several mm and, when derived from welding beads, may have relatively small particle diameters about equal to those of oxide scale) are carried by an exhaust gas flow and arrive at a honeycomb structure.

[0017] The reason why an exhaust manifold is produced using stainless steel, is as follows. An exhaust manifold of light weight and small heat capacity can be produced; the light weight can contribute to an improved fuel consumption of automobile and the small heat capacity can prevent the lowering of exhaust gas temperature and promote the early activation of catalyst.

[0018] Further, with respect to the converter system which is currently in main use, the present inventors made an intensive study on a relation between the manner in which the converter system is provided relative to an exhaust manifold and the erosion of the honeycomb structure. As a result, the followings were found.

(1) In a converter system as shown in Fig. 1 and Fig. 2 wherein the exhaust pipes from the exhaust manifold of each engine cylinder (cylinders of engine are various, for example, two cylinders and four cylinders) are directly connected to the cone section 7 of converter system as exhaust gas inlet pipes 5, an exhaust gas 21 is injected onto a honeycomb structure 10 at a high speed without making no substantial spread. Moreover, from, for example, the necessity of exact measurement by oxygen sensor, most exhaust pipes 5 are provided, as shown in Fig. 1, so that exhaust gases 21 discharged from exhaust pipes 5 intersect each other and are injected concentratedly onto the central area of the end face of honeycomb structure 10, or, as shown in Fig. 2, so that exhaust gases 21 intersect each other before their arrival at the end face of honeycomb structure and are injected concentratedly onto the area of the honeycomb structure end face near the outer peripheral area of end face. Therefore, in this type

portion near the outer peripheral portion of honeycomb structure, and a partition wall group consisting only of partition walls having a thickness larger than the average partition wall thickness is provided so as to include the central portion of honeycomb structure located inside the honeycomb portion near the outer peripheral portion of honeycomb structure.

(3) A honeycomb structure in which a plurality of through-holes extending in the axial direction are formed by a plurality of partition walls, characterized in that

in the whole portion of honeycomb structure in which the partition walls are provided, those partition walls having a thickness larger than the average thickness of all partition walls and those partition walls having a thickness smaller than the average partition wall thickness are provided in a mixed state, and

a partition wall group containing those partition walls having a thickness larger than the average partition wall thickness, relatively in a large amount is provided in a particular portion of honeycomb structure, and a partition wall group containing those partition walls having a thickness smaller than the average partition wall, relatively in a large amount is provided in other portion.

[0026] For the honeycomb structure (1), there can be mentioned, as examples of more in-depth embodiments, a honeycomb structure wherein the partition wall group consisting of those partition walls having a thickness larger than the average thickness of all partition walls and those partition walls having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the honeycomb structure portion near the outer peripheral portion of honeycomb structure, and the partition wall group consisting only of partition walls having a thickness smaller than the average partition wall thickness is provided so as to include a honeycomb structure central portion located inside the honeycomb structure portion near the outer peripheral portion of honeycomb structure; and a a honeycomb structure wherein the partition wall group consisting only of partition walls having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the honeycomb structure portion near the outer peripheral portion of honeycomb structure, and the partition wall group consisting of those partition walls having a thickness larger than the average partition wall thickness and those partition walls having a thickness smaller than the average partition wall thickness is provided so as to include a honeycomb structure central portion located inside the honeycomb structure portion near the outer peripheral portion of honeycomb structure.

[0027] In the honeycomb structure (2), the plurality of partition walls may have such thicknesses as decrease stepwise or continuously from the central portion of honeycomb structure towards the outer periphery of honeycomb structure. In the honeycomb structure (3), a proportion of the partition walls having a thickness smaller than the average partition wall thickness may increase stepwise or continuously from the central portion of honeycomb structure towards the outer periphery of honeycomb structure. In each of the honeycomb structures (1) to (3), the partition walls having a thickness larger than the average partition wall thickness and the partition walls having a thickness smaller than the average partition wall thickness may be provided irregularly.

[0028] On the other hand, according to the present invention, there is provided a honeycomb structure having a plurality of through-holes divided by a plurality of partition walls and extending in the axial direction, characterized in that

the plurality of partition walls are constituted by a plurality of partition walls having different thicknesses, and

partition walls having a thickness larger than the average thickness of all partition walls and partition walls having a thickness smaller than the average partition wall thickness are provided irregularly. (This honeycomb structure is hereinafter referred to as "second honeycomb structure" in some cases.)

[0029] In each of the first and second honeycomb structures, the partition walls having a thickness smaller than the average partition wall thickness or the partition walls having a thickness larger than the average partition wall thickness may be constituted by at least two kinds of partition walls of different thicknesses.

[0030] When foreign matter having relatively large particle diameters is generated, of the plurality of partition walls, those partition walls forming, in the honeycomb portion near the outer peripheral portion of honeycomb structure, through-holes located at the positions which a line normal to the outer peripheral surface of honeycomb structure passes, and having an angle of ±20° to the normal line, are preferred to be constituted by partition walls having a thickness larger than the average partition wall thickness. In a converter system wherein an exhaust gas is injected onto an area of honeycomb structure end face ranging from the central area to the outer peripheral area, of the plurality of partition walls, those partition walls forming through-holes located at the positions which a line normal to the outer peripheral surface of honeycomb structure passes, and having an angle of 70 to 110° to the normal line, are preferred to be constituted by partition walls having a thickness larger than the average partition wall thickness.

[0031] In each of the honeycomb structures of the present invention, the strength of the whole honeycomb structure can be reinforced by making the thickness of the outer wall of honeycomb structure at least two times those of partition walls. The strength of the whole honeycomb structure can also be reinforced by plugging the

Fig. 5 is a sectional view showing one example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 6 is a sectional view showing other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 7 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 8 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 9 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 10 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 11 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 12 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 13 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 14 is a partially enlarged view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 15 is a partially enlarged view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 16 is a sectional view showing still other example of the arrangement pattern of partition walls having a thickness smaller than the average thickness of all partition walls and partition walls having a thickness larger than the average partition wall thickness, in the first honeycomb structure of the present invention.

Fig. 17 is a graph showing one example in which the thicknesses of partition walls are changed stepwise in the honeycomb structure of the present invention.

Fig. 18 is a graph showing other example in which the thicknesses of partition walls are changed stepwise in the honeycomb structure of the present invention.

Fig. 19 is a graph showing one example in which the thicknesses of partition walls are changed irregularly in the honeycomb structure of the present invention.

Best Mode for Carrying Out the Invention

[0039] Hereinafter, the modes for carrying out the present invention are described specifically with reference to the accompanying drawings.

1. First honeycomb structure

[0040] As shown in Figs. 1 to 4, the first honeycomb structure 10 of the present invention is a honeycomb structure 10 in which a plurality of through-holes 3 extending in the axial direction are formed by a plurality of partition walls, wherein the plurality of partition walls are constituted by a plurality of partition walls 1 and 2 having different thicknesses and, of the plurality of partition walls 1 and 2 having different thicknesses, those partition walls 2 having a thickness larger than the average thickness of all partition walls are provided at a higher proportion in a particular portion of honeycomb structure

erage partition wall thickness are provided, with referring to drawings.

[0051] Figs. 5 to 16 are each a sectional view schematically showing a state in which, in the first honeycomb structure, the partition walls having a thickness smaller than the average partition wall thickness and the partition walls having a thickness larger than the average partition wall thickness are arranged.

[0052] As shown in Figs. 5 to 9, as one embodiment of the first honeycomb structure, there can be mentioned a honeycomb structure in which a plurality of through-holes 4 extending in the axial direction are formed by a plurality of partition walls 1 and 2, wherein the plurality of partition walls 1 and 2 are constituted by a plurality of partition walls having different thicknesses, and a partition wall group 11 consisting of those partition walls 2 having a thickness larger than the average thickness of all partition walls and those partition walls 1 having a thickness smaller than the average partition wall thickness is provided in a particular portion of honeycomb structure and a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in other portion.

[0053] In this honeycomb structure 10, a partition wall group consisting of partition walls 2 having a thickness larger than the average partition wall and partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to correspond to the exhaust-gas-injected area of honeycomb structure end face, whereby the erosion resistance of the honeycomb structure can be enhanced effectively; further, a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in other portion of honeycomb structure not corresponding to the exhaust gas-injected area of honeycomb structure end face, whereby the honeycomb structure can maintain a good warm-up property and exhibit a high purifiability for exhaust gas. Also, the honeycomb structure has an advantage of increased strength as compared with when thick partition walls are provided only in the outer peripheral portion of honeycomb structure. Moreover, in this honeycomb structure, since partition walls 2 having a thickness larger than the average partition wall and partition walls 1 having a thickness smaller than the average partition wall thickness are provided in a mixed state, a good warm-up property, in particular, can be exhibited. In addition, since in the portion of honeycomb structure wherein partition walls 2 having a thickness larger than the average partition wall thickness are provided, thick partition walls of high heat capacity and thin partition walls of low heat capacity exist in a mixed state, there is a mild temperature gradient between the above portion and a honeycomb structure portion wherein a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided, and the thermal stress at the boundary of the two portions can be reduced.

[0054] As such a honeycomb structure, there can be mentioned, for example, a honeycomb structure such as shown in Figs. 5 to 7, wherein a partition wall group 11 consisting of partition walls 2 having a thickness larger than the average partition wall thickness and partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the of the portion of honeycomb structure near the outer peripheral portion, and a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to include a honeycomb structure central portion located inside the portion of honeycomb structure near the outer peripheral portion; and a honeycomb structure such as shown in Figs. 8 and 9, wherein a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the portion of honeycomb structure near the outer peripheral portion, and a partition wall group 11 consisting of partition walls 2 having a thickness larger than the average partition wall thickness and partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to include a honeycomb structure central portion located inside the portion of honeycomb structure near the outer peripheral portion.

[0055] In the former honeycomb structure, the erosion resistance can be enhanced effectively when the exhaust gas-injected area 4 of honeycomb structure end face is concentrated at the area of end face near its peripheral area as in a converter system shown in Fig. 2, or when erosion takes place concentratedly at the area of end face area hear its peripheral area by the local circulating flow 22 of exhaust gas as in a converter system shown in Fig. 3 or 4. Meanwhile in the latter honeycomb structure, the erosion resistance can be enhanced effectively when the exhaust gas-injected area of honeycomb structure end face is concentrated at the central area of honeycomb structure end face as in a converter system shown in Fig. 1 or Fig. 3.

[0056] As the former honeycomb structure, there can be mentioned (1) a honeycomb structure such as shown in Fig. 5, wherein a partition wall group 11 consisting of partition walls 2 having a thickness larger than the average partition wall thickness and partition walls 1 having a thickness smaller than the average partition wall thickness is provided in the portion of honeycomb structure near the outer peripheral portion, and a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in a honeycomb structure central portion located inside the portion of honeycomb structure near the outer peripheral portion; (2) a honeycomb structure such as shown in Fig. 6, wherein a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in a honeycomb structure portion in-

structure can be increased, and the shape retainability during molding and the canning resistance can be enhanced as compared with the case of the honeycomb structure shown in Fig. 8. Needless to say, since even partition walls 1 having a thickness larger than the average partition wall thickness exist in, for example, the central portion where partition walls 2 having a thickness larger than the average partition wall thickness exist, an increase in heat capacity and pressure loss can be suppressed in the central portion, etc., making possible an improvement in warm-up property, etc. and further an excessive increase in rigidity can be suppressed, making it possible to prevent a reduction in thermal shock resistance.

[0066] Incidentally, in a converter system shown in Fig. 3(a) wherein an exhaust gas inlet pipe 5 is provided obliquely above relative to the exhaust gas-injected end face of honeycomb structure, the foreign matter in an exhaust gas 21 which has arrived at the end face of honeycomb structure 10, collides with the inner surface of a cone section 7 and is diverged, slides on the area of end face near the periphery of end face in the circumferential direction of end face, is carried by the flow of exhaust gas and again passes (slides on) the central area of end face, as shown in Fig. 3(b). Therefore, erosion is generated mainly at the area of end face near the periphery of end face and at the central area of end face. Therefore, in this type of converter system, it is preferred that, as shown in Fig. 3(b), there is used such a honeycomb structure as a partition wall group 11 consisting of partition walls 2 having a thickness larger than the average partition wall thickness and partition walls 1 having a thickness smaller than the average partition wall thickness is provided in at least part of the portion of honeycomb structure near the outer peripheral portion and in at least part of the central portion of honeycomb structure, and a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in an intermediate portion located between the above two portions.

[0067] Next, description is made on other embodiment of the first honeycomb structure, shown in Figs. 10 and 11.

[0068] As the other embodiment of the first honeycomb structure, there can be mentioned a honeycomb structure 10 of Figs. 10 and 11, wherein a plurality of through-holes extending in the axial direction are formed by a plurality of partition walls 1 and 2, the plurality of partition walls 1 and 2 are constituted by a plurality of partition walls having different thicknesses, a partition wall group 13 consisting only of partition walls 2 having a thickness larger than the average partition wall thickness is provided in a particular portion of honeycomb structure, and a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in other portion of honeycomb structure.

[0069] In this honeycomb structure 10, since a partition wall group consisting only of partition walls 2 having a thickness larger than the average partition wall thickness is provided so as to correspond to the exhaust gas-injected area of honeycomb structure end face, the erosion resistance can be enhanced effectively; further, since a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided in other honeycomb structure portion not corresponding to the exhaust gas-injected area of honeycomb structure end face, a good warm-up property can be maintained and a high purifiability for exhaust gas can be exhibited. Also the honeycomb structure has an advantage of higher structure strength as compared with when thick walls are employed only at the outer peripheral portion of honeycomb structure.

[0070] As such a honeycomb structure, there can be mentioned a honeycomb structure shown in Figs. 10 and 11, wherein a plurality of partition walls 1 and 2 are constituted by a plurality of partition walls having different thicknesses, a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the portion of honeycomb structure near the outer peripheral portion, and a partition wall group 13 consisting only of partition walls 2 having a thickness larger than the average partition wall thickness is provided so as to include the central portion located inside the portion of honeycomb structure near the outer peripheral portion; and a honeycomb structure shown in Figs. 10 and 11, wherein a plurality of partition walls 1 and 2 are constituted by a plurality of partition walls having different thicknesses, a partition wall group 13 consisting only of partition walls 2 having a thickness larger than the average partition wall thickness is provided in so as to include at least part of the portion of honeycomb structure near the outer peripheral portion, and a partition wall group 12 consisting only of partition walls 1 having a thickness smaller than the average partition wall thickness is provided so as to include the central portion located inside the portion of honeycomb structure near the outer peripheral portion.

[0071] In the case of the former honeycomb structure, the corrosion resistance can be enhanced effectively when the exhaust gas-injected area of honeycomb structure end face is concentrated at the central area of end face as in the converter system of Fig. 1 or Fig. 3.

[0072] Particularly in this honeycomb structure, since only partition walls 2 having a thickness larger than the average partition wall thickness are used in the central portion corresponding to the exhaust gas-injected are of honeycomb structure end face, the erosion resistance is large and, further, as compared with the case of a honeycomb structure wherein partition walls 2 having a thickness larger than the average partition wall thickness and partition walls 1 having a thickness smaller than the average partition wall thickness are provided

this embodiment, when erosion takes place mainly in the partition walls of central portion but on the whole area of honeycomb structure end face and the erosion phenomenon decreases gradually toward the outer peripheral area of end face, the erosion resistance can be enhanced effectively by constituting both of partition walls 1 having a thickness smaller than the average partition wall thickness and partition walls 2 having a thickness larger than the average partition wall thickness, using at least two kinds of partition walls of different thicknesses and making the partition wall thickness smaller stepwise or gradually from the central portion of honeycomb structure 10 toward the outer periphery.

[0081] Next, description is made on still other embodiment of the first honeycomb structure.

[0082] As the still other embodiment of the first honeycomb structure, there can be mentioned a honeycomb structure wherein a plurality of through-holes extending in the axial direction are formed by a plurality of partition walls and wherein, in the whole honeycomb structure portion in which the plurality of partition walls are provided, partition walls having a thickness larger than the average thickness of all partition walls and partition walls having a thickness smaller than the average partition wall thickness are provided in a mixed state, a partition wall group containing the partition walls having a thickness larger than the average partition wall thickness, in a relatively large amount is provided in a particular portion, and a partition wall group containing the partition walls having a thickness smaller than the average partition wall thickness, in a relatively large amount is provided in other portion.

[0083] In this honeycomb structure, since the partition wall group containing the partition walls having a thickness larger than the average partition wall thickness, in a relatively large amount is provided in a particular portion so as to correspond to the exhaust gas-injected area of honeycomb structure end face, the erosion resistance can be enhanced effectively. Further, since the partition wall group containing the partition walls having a thickness smaller than the average partition wall thickness, in a relatively large amount is provided in other portion not corresponding to the exhaust gas-injected area of honeycomb structure end face, a good warm-up property can be maintained and a high purifiability for exhaust gas can be exhibited. Also, there is an advantage that the thermal shock resistance and structure strength can be increased as compared with when only the partition walls at the outer peripheral portion of honeycomb structure are made thick. Also, in this honeycomb structure, since the partition walls having a thickness larger than the average partition wall thickness and the partition walls having a thickness smaller than the average partition wall thickness are provided in a mixed state in the whole portion, a good warm-up property, in particular, can be exhibited and thermal stress concentration can be minimized. Also, in this honeycomb structure, the erosion resistance can be enhanced effectively when erosion takes place mainly in a particular area of end face but slightly in the whole end face area.

[0084] Incidentally, in this honeycomb structure as well, the partition walls having a thickness smaller than the average partition wall thickness may be constituted by at least two kinds of partition walls having different thicknesses, and the partition walls having a thickness larger than the average partition wall thickness may be constituted by at least two kinds of partition walls having different thicknesses.

[0085] Next, the still other embodiment of the first honeycomb structure, shown in Fig. 14 or 15 is described.

[0086] In the first honeycomb structure 10 shown in Fig. 14 or 15, when the direction of exhaust gas injection has a particular angle to the direction of through-holes 3 as in the converter systems shown in Figs. 1 to 3, it is preferred that, of the plurality of partition walls, those partition walls forming through-holes 3 located at the positions which a line 20 normal to the outer peripheral surface of honeycomb structure 10 passes, and having an angle of 70 to 110° to the normal line, are constituted by partition walls 2 having a thickness larger than the average partition wall thickness; it is more preferred that those partition walls having an angle of 80 to 100° are constituted by partition walls 2 having a thickness larger than the average partition wall thickness; and it is particularly preferred that those partition walls having an angle of 85 to 95° are constituted by partition walls 2 having a thickness larger than the average partition wall thickness.

[0087] When the injection direction of exhaust gas has an particular angle to the direction of through-holes 3, the partition walls provided at the positions almost normal to the movement direction of foreign matter in exhaust gas undergo the shock by foreign matter easily; therefore, the erosion resistance of such a honeycomb structure can be enhanced effectively by constituting the partition walls which undergo such a shock easily, using partition walls 2 having a thickness larger than the average partition wall thickness.

[0088] Incidentally, the reason for the above range of 70 to 110° is that when even partition walls outside this range are constituted using partition walls 2 having a thickness larger than the average partition wall thickness, the drawback of reduction in warm-up property due to increase in heat capacity may be larger than the effect of enhancement in erosion resistance.

[0089] Meanwhile, when foreign matter having particle diameters of 1 mm or more is contained in a large amount in an exhaust gas, it is preferred as shown in Fig. 16 that, of the plurality of partition walls, those partition walls forming, in the portion of honeycomb structure 10 near the outer peripheral portion, through-holes 3 located at the positions which a line 20 normal to the outer peripheral surface of honeycomb structure 10 passes, and having an angle of ±20° to the normal line 20, are constituted by partition walls 2 having a thickness larger than the average partition wall thickness; it

may become larger; when the proportions are larger than 1:3, it may be difficult to obtain a desired erosion resistance.

[0101] Preferably, the first honeycomb structure is molded in an integrated form of outer peripheral wall and partition walls by extrusion molding, for a high productivity and a low cost. As the method for allowing partition walls to have a larger thickness, there can be mentioned, for example, a method of subjecting a molding die having a uniform slit width, to electric spark machining at the die portions corresponding to the larger thickness partition wall portions of honeycomb structure to obtain a die having desired slit widths, and then conducting extrusion molding using the die; and a method of applying plating to a molding die having a uniform slit width to obtain a die in which the thickness of plating is small at the die portions corresponding to the larger thickness partition wall portions of honeycomb structure, and then conducting extrusion molding using the die.

[0102] In the first honeycomb structure, there is no particular restriction as to the thickness of outer peripheral wall. However, when the proportion of thin partition walls having a thickness smaller than the average partition wall thickness is higher than the proportion of partition walls having a thickness larger than the average partition wall thickness, in the vicinity of the outer peripheral portion of honeycomb structure, the thickness of outer peripheral wall is preferred to be at least two times the partition wall thickness in order to increase the strength of whole honeycomb structure. When an exhaust gas hits the outer peripheral wall of honeycomb structure or when foreign matter slides on the area of honeycomb structure end face including the outer peripheral area, the outer peripheral wall is preferred to be even thicker.

[0103] There is no particular restriction as to the material for the first honeycomb structure. There can be mentioned, for example, at least one kind of ceramic material selected from the group consisting of cordierite, alumina, mullite, lithium aluminum silicate, aluminum titanate, titania, zirconia, silicon nitride, aluminum nitride and silicon carbide; a composite material thereof; and an adsorptive material such as active carbon, silica gel, zeolite or the like. A heat-resistant metal material such as stainless steel or the like may also be used.

[0104] As mentioned above, when the average partition wall thickness of honeycomb structure is as small as 0.1 mm or less, the honeycomb structure is low in mechanical strength and erosion resistance; therefore, in such a case, the material for honeycomb structure is preferred to be densified (about 10 to 25% in porosity) for enhancement in mechanical strength and erosion resistance.

[0105] In this case, the honeycomb structure may be densified in the whole portion or locally (part of the end face). However, the honeycomb structure is preferably densified in the whole portion because it can enhance the mechanical strength to canning and the total mechanical strength and further can prevent the temperature increase caused by an increase in heat capacity. When the honeycomb structure is densified locally, the discontinuity between the densified portion and other portion may incur a reduction in thermal shock resistance; therefore, the density of honeycomb structure is preferred to be continuously gradient. Since excessive densification may invite a reduction in thermal shock resistance owing to an increase in thermal expansion coefficient, the porosity is preferred to be controlled in the above-mentioned range.

[0106] In the first honeycomb structure, it is preferred to load a catalyst component on the plurality of partition walls. As the catalyst component, there can be mentioned, for example, Pt, Pd and Rh. The first honeycomb structure can be made into a honeycomb filter by plugging the through-holes alternately at each end face, using a plugging material. There is no particular restriction as to the plugging material, and there can be used, for example, the same material as the above-mentioned material used for the first honeycomb structure.

2. Second honeycomb structure

[0107] The second honeycomb structure of the present invention is a honeycomb structure having a plurality of through-holes which are divided by a plurality f partition walls and extend in the axial direction, wherein the plurality of partition walls are constituted by a plurality of partition walls having different thicknesses, and partition walls having a thickness larger than the average thickness of all partition walls and partition walls having a thickness smaller than the average partition wall thickness are provided irregularly.

[0108] Thereby, the erosion resistance of the second honeycomb structure can be enhanced effectively even under such conditions that the foreign matter in exhaust gas collides with individual partition walls unpredictably and irregularly Further, the thermal shock resistance can be increased by relaxation of the concentration of thermal stress.

[0109] The second honeycomb structure is the same as the above-mentioned first honeycomb structure except that the partition walls having a thickness larger than the average partition wall thickness and the partition walls having a thickness smaller than the average partition wall thickness are provided irregularly. Therefore, no description is made here on the common points.

[0110] In the second honeycomb structure, the proportion of the partition walls having a thickness larger than the average partition wall thickness and the proportion of the partition walls having a thickness smaller than the average partition wall thickness, in the whole structure may be different as in the above-mentioned first honeycomb structure. However, the proportions are preferred to be uniform in the whole structure when injection of exhaust gas is made on the whole area of hon-

comb structure after the test.

(Result of evaluation)

[0120] The above erosion test was conducted using honeycomb structures obtained by loading a catalyst component on each of the honeycomb structures produced in Example 1 and Comparative Example 1. As a result, the erosion resistance in the honeycomb structure of Example 1 was improved by about 40% as compared with that in the honeycomb structure of Comparative Example 1.

[0121] Incidentally, the same test was conducted by changing the amount of catalyst loaded, in each of the above honeycomb structures. A similar result was obtained.

Industrial Applicability

[0122] As described above, according to the present invention there can be provided a honeycomb structure, etc., all of which satisfy the recent year's requirements of increased warm-up property connected with purification ability and reduction in the amount of harmful substance emitted right after engine start and yet have a sufficient mechanical strength to external pressure, a large erosion resistance and a large thermal shock resistance.

Claims

1. A honeycomb structure in which a plurality of through-holes extending in the axial direction are formed by a plurality of partition walls, **characterized in that**

   said plurality of partition walls are constituted by a plurality of partition walls having different thicknesses, and

   of said plurality of partition walls having different thicknesses, those partition walls having a thickness larger than the average thickness of all partition walls are provided at a higher proportion in a particular portion of the honeycomb structure whole portion having partition walls than in other portion.

2. A honeycomb structure in which a plurality of through-holes extending in the axial direction are formed by a plurality of partition walls, **characterized in that**

   said plurality of partition walls are constituted by a plurality of partition walls having different thicknesses, and

   a partition wall group consisting of those partition walls having a thickness larger than the average thickness of all partition walls and those partition walls having a thickness smaller than the average partition wall thickness is provided in a particular portion of the honeycomb structure whole portion having partition walls, and a partition wall group consisting only of partition walls having a thickness smaller than the average partition wall thickness is provided in other portion.

3. A honeycomb structure according to Claim 2, wherein the partition wall group consisting of those partition walls having a thickness larger than the average thickness of all partition walls and those partition walls having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the honeycomb structure portion near the outer peripheral portion of honeycomb structure, and the partition wall group consisting only of partition walls having a thickness smaller than the average partition wall thickness is provided so as to include a honeycomb structure central portion located inside the honeycomb structure portion near the outer peripheral portion of honeycomb structure.

4. A honeycomb structure according to Claim 2, wherein the partition wall group consisting only of partition walls having a thickness smaller than the average partition wall thickness is provided so as to include at least part of the honeycomb structure portion near the outer peripheral portion of honeycomb structure, and the partition wall group consisting of those partition walls having a thickness larger than the average partition wall thickness and those partition walls having a thickness smaller than the average partition wall thickness is provided so as to include a honeycomb structure central portion located inside the honeycomb structure portion near the outer peripheral portion of honeycomb structure.

5. A honeycomb structure in which a plurality of through-holes extending in the axial direction are formed by a plurality of partition walls, **characterized in that**

   said plurality of partition walls are constituted by a plurality of partition walls having different thicknesses, and

   a partition wall group consisting only of partition walls having a thickness smaller than the average thickness of all partition walls is provided so as to include at least part of the honeycomb structure portion near the outer peripheral portion of honeycomb structure, and a partition wall group consisting only of partition walls having a thickness larger than the average partition wall thickness is provided so as to include the central portion of honeycomb structure located inside the honeycomb portion near the outer peripheral portion of honeycomb structure.

21. A converter system comprising a honeycomb structure or honeycomb filter set forth in any of Claims 1 to 20, an exhaust gas inlet pipe for introducing an exhaust gas into the honeycomb structure or honeycomb filter, a case for holding the honeycomb structure or honeycomb filter, and a cone section which is connected to the case and to which the exhaust gas inlet pipe is connected.

FIG.2

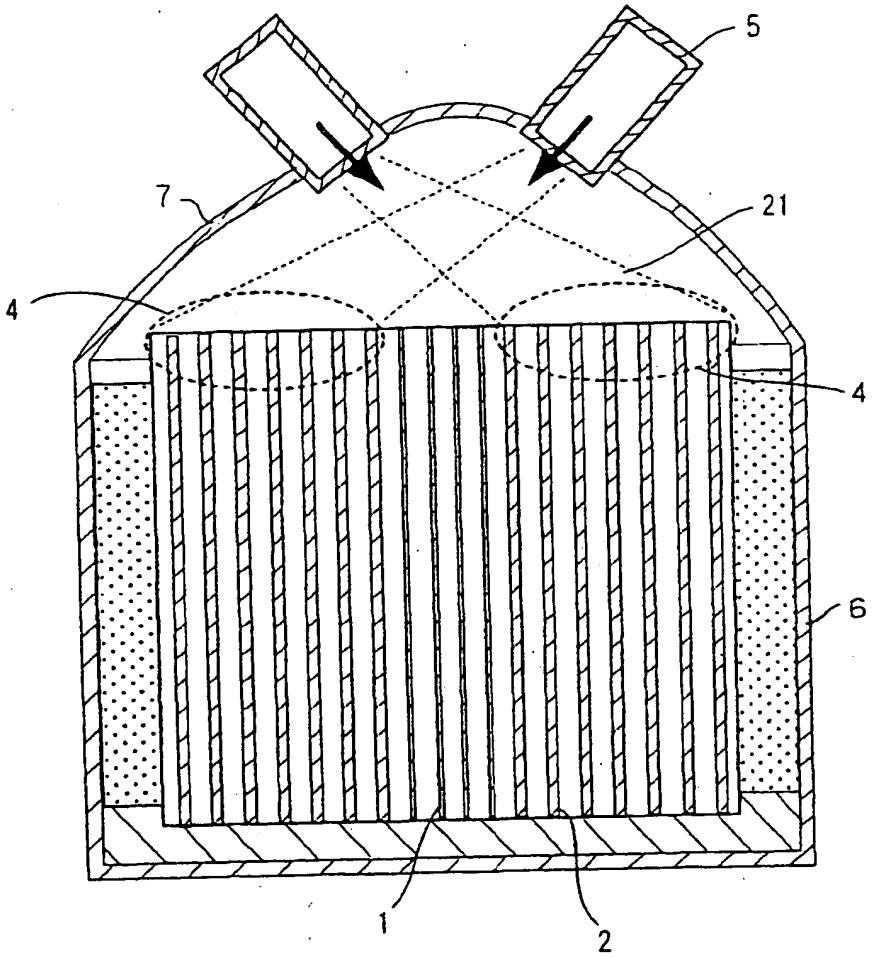

FIG.4

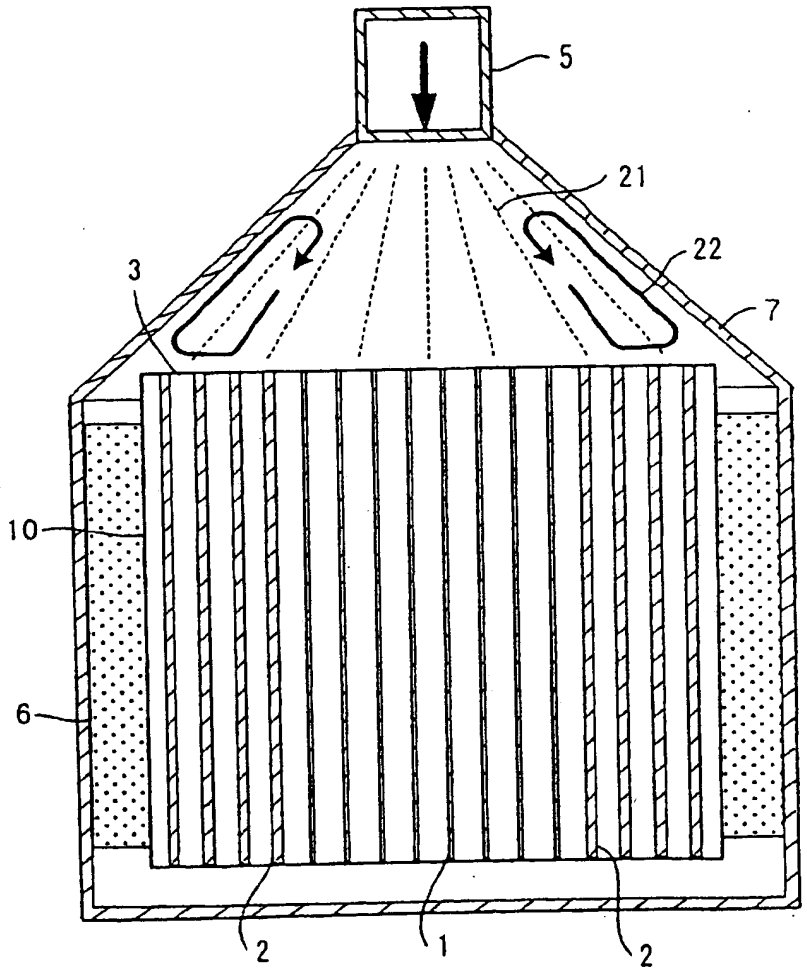

FIG.7

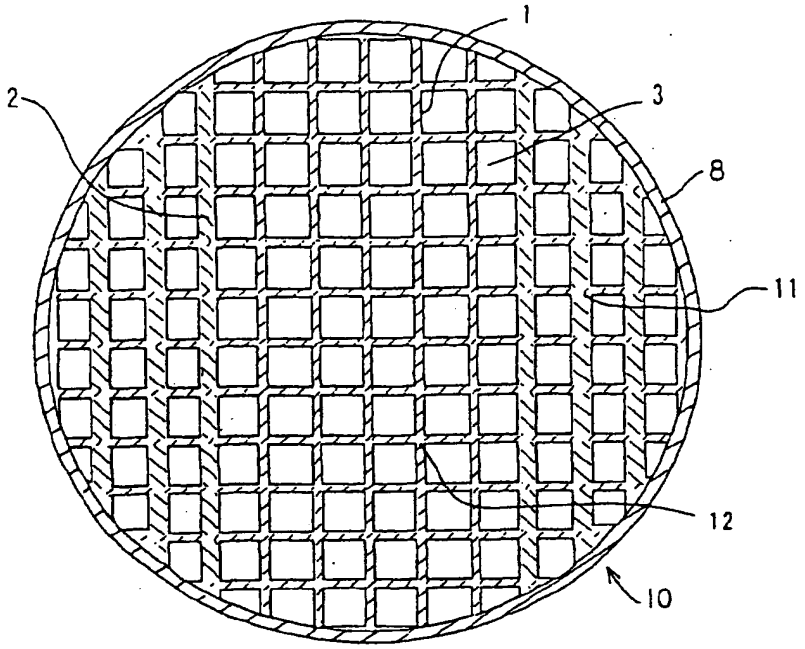

FIG.8

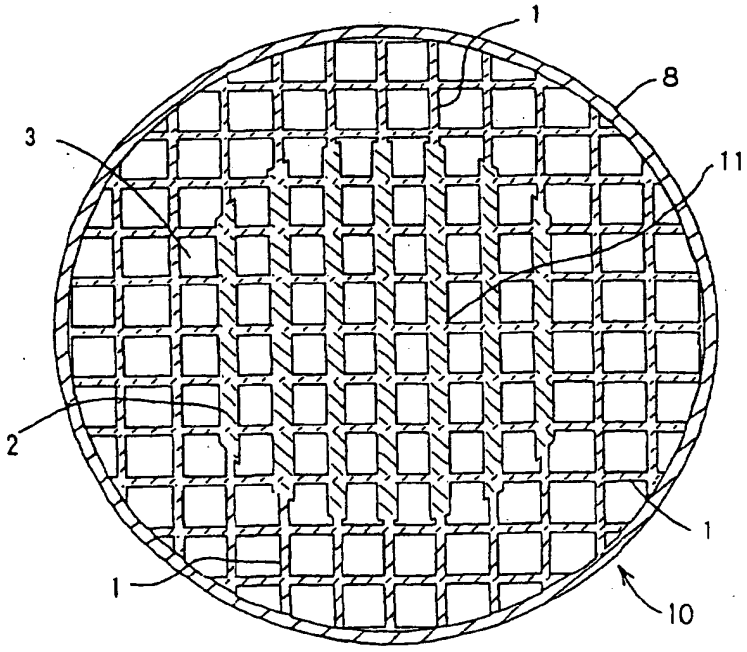

FIG. 11

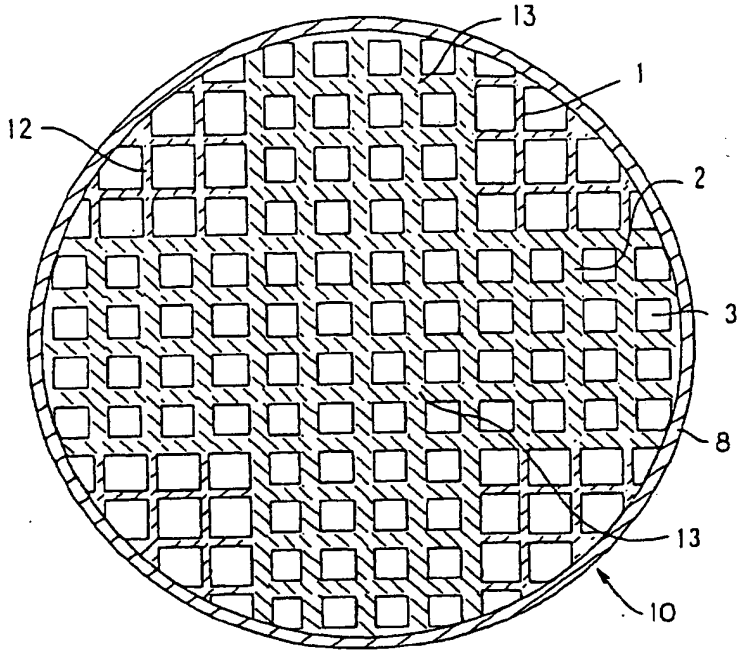

FIG. 12

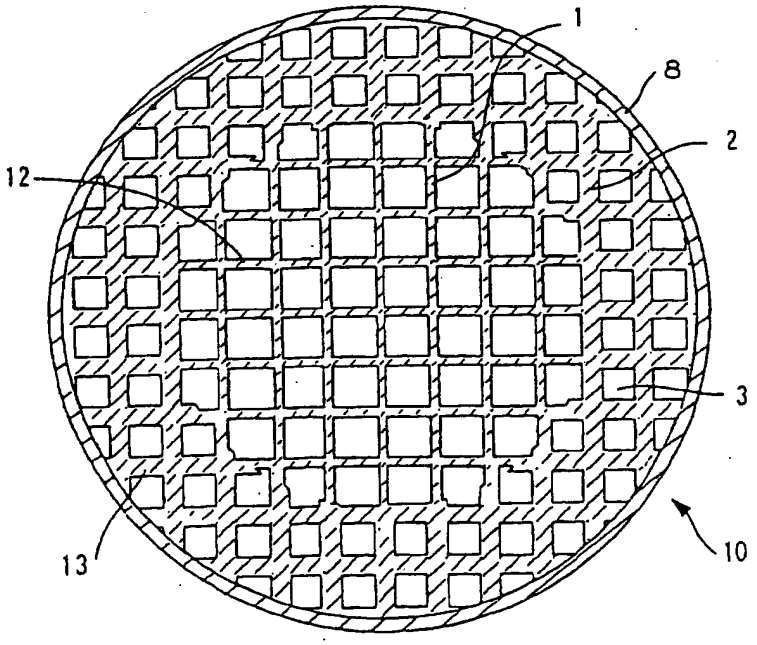

FIG.14

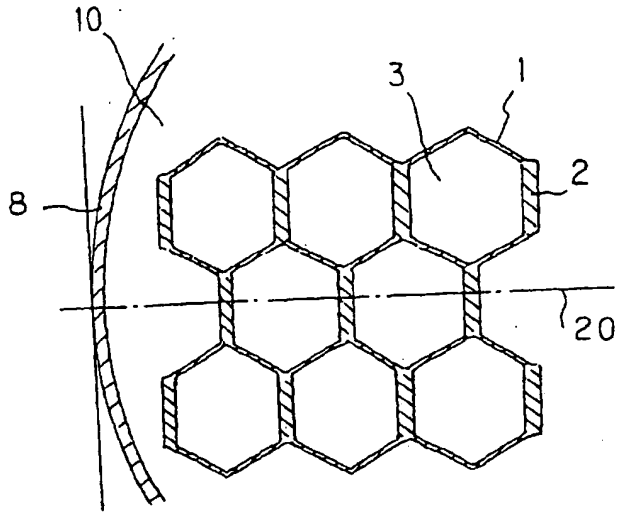

FIG.15

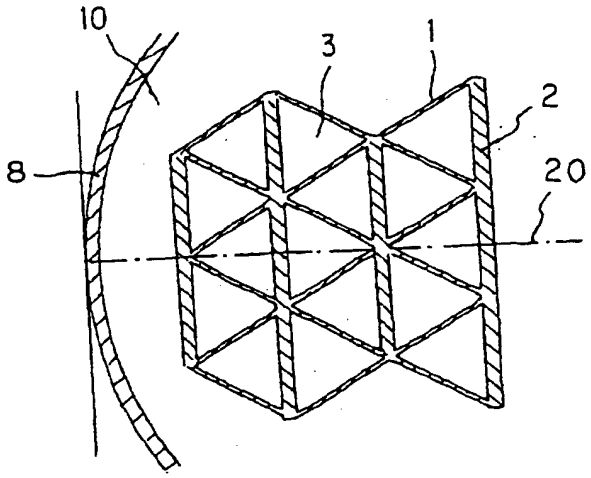

FIG. 17

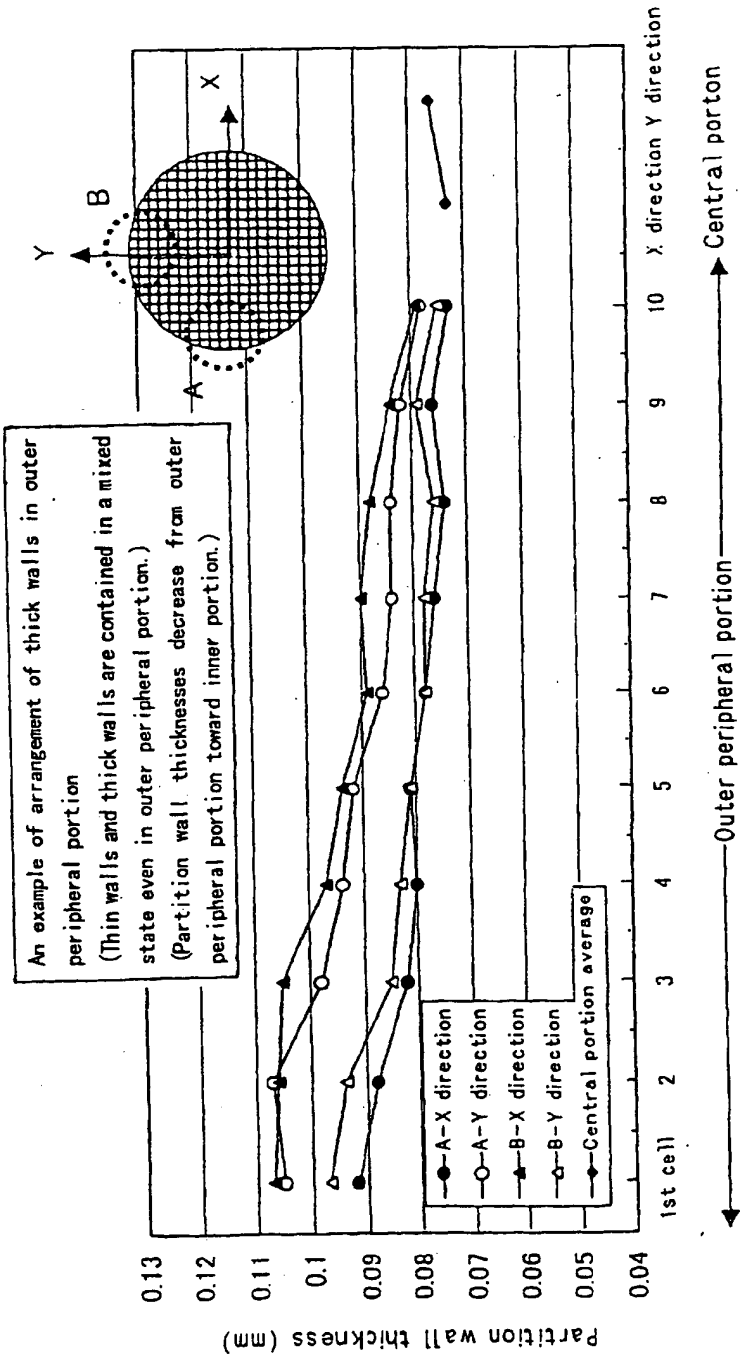

FIG.19